GEOLOGY OF THE BELL GIN QUADRANGLE

WILLIAMSON COUNTY, TEXAS

APPROVED:

[redacted]

APPROVED:

[redacted]

Dean of the Graduate School

GEOLOGY OF THE BELL GIN QUADRANGLE

WILLIAMSON COUNTY, TEXAS

THESIS

Presented to the Faculty of the Graduate School of

The University of Texas in Partial Fulfillment

of the Requirements

For the Degree of

MASTER OF ARTS

by

Billy Walls, B. A.

Austin, Texas

August, 1950

TABLE OF CONTENTS

Page

ILLUSTRATIONS

FIGURES

PLATES

After Page

PLATES

INTRODUCTION

This paper is a geologic study of the Georgetown, Grayson, Buda, Pepper, Eagle Ford, and Austin formations in the Bell Gin quadrangle, Williamson County, Texas. The major problem involved is a critical determination of the value of mapping the members of the Georgetown formation which were previously established (Adkins and Arick, 1930) in Bell County, Texas. This paper serves also as a test of the practical mapping value of the zones in the Austin formation which were previously established (Marks, 1950) in the Jonah quadrangle, Williamson County, Texas.

The Bell Gin quadrangle is situated in the south-central part of Williamson County, 28 miles north of Austin, Texas, on U. S. Highway 81. (Fig. 1.) It includes the eastern limits of the city of Georgetown which is located in the northwestern portion of the area. The name of the quadrangle is derived from the cotton gin, Bell, in the south-central part of the area. The area embraces a five minute quadrangle with the boundaries 30°40' and 30°35' North Latitude and 97°35' and 97°40' West Longitude. The eastern boundary is indicated by a north-south country road which intersects State Highway 104 at the San Gabriel River; the northern boundary is marked roughly by the San Gabriel River; while the western boundary is indicated by an imaginary line through Southwestern University, Georgetown, Texas. On the south, the area is bounded by an imaginary line 3.3 miles south of Georgetown, Texas. The quadrangle consists of approximately 28 square miles.

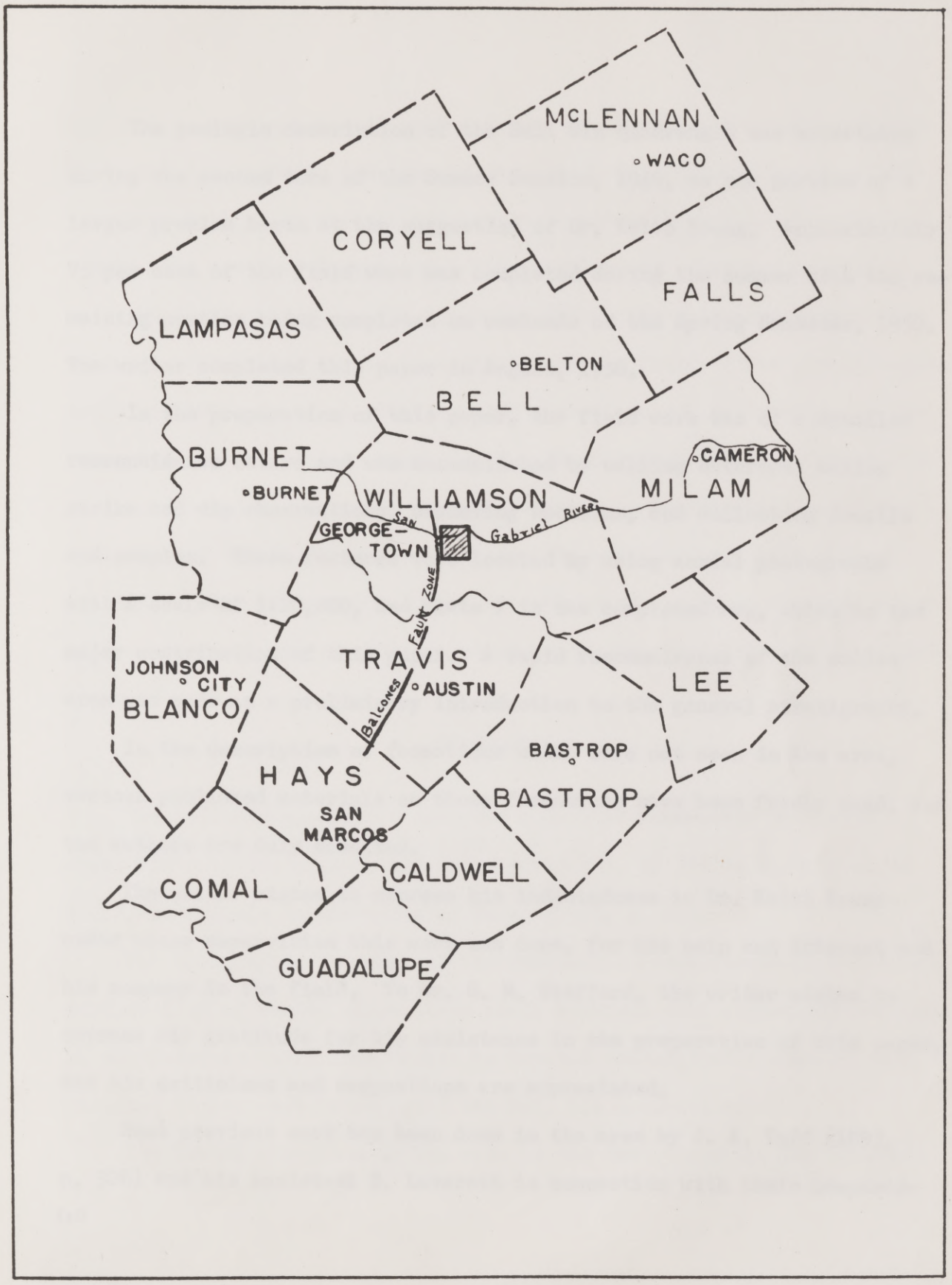


Figure 1.

INDEX MAP OF CENTRAL TEXAS SHOWING LOCATION OF BELL GIN QUADRANGLE

The geologic description of the Bell Gin quadrangle was undertaken during the second term of the Summer Session, 1949, as one portion of a larger problem begun at the suggestion of Dr. Keith Young. Approximately 75 per cent of the field work was completed during the summer with the remaining portion being completed on weekends of the Spring Semester, 1950. The writer completed this paper in August, 1950.

In the preparation of this paper, the field work was of a detailed reconnaisance nature and was accomplished by walking outcrops, making strike and dip observations, measuring sections, and collecting fossils and samples. These features were located by using aerial photographs with a scale of 1:20,000, and Plate I is the completed map, which is the major contribution of this paper. A rapid reconnaisance of the entire area was made as a preliminary introduction to the general stratigraphy.

In the description of formations which were not seen in the area, various published materials on those formations have been freely used, and the authors are duly credited.

The writer wishes to express his indebtedness to Dr. Keith Young under whose supervision this work was done, for his help and interest and his company in the field. To Mr. G. M. Stafford, the writer wishes to express his gratitude for his assistance in the preparation of this paper, and his criticisms and suggestions are appreciated.

Some previous work has been done in the area by J. A. Taff (1893, p. 326) and his assistant S. Leverett in connection with their Lampasas-

Williamson section. Detail work was done by these two men along the San Gabriel River opposite the town of Georgetown for the purpose of verifying their work along their northwest-southeast section line which passed a half-mile south of Georgetown. This problem was suggested to them by R. T. Hill (1899-1900, p. 23) who later (Hill, 1901) incorporated their work into the United States Geological Survey's Twenty-first Annual Report. Later, in 1925, Dr. F. L. Whitney made several fossil collections in the area, but the material is unpublished. In 1932 W. S. Adkins wrote a very excellent publication on the Mesozoic Systems in Texas with a brief description of the Del Rio formation one mile east of Georgetown, Texas (p. 390). The changes made in the present paper are in no way criticisms of the previous authors, but represent a more detailed study along certain lines of work.

PHYSIOGRAPHY

The Bell Gin quadrangle occupies a part of Fenneman's West Gulf Coast Plain (1938, p. 102) and forms part of R. T. Hill's Black Prairie and Grand Prairie subprovinces of Texas (1901, p. 26).

The topographic features of the quadrangle are a result of differential erosion of varied sedimentary rocks combined with structural features of the Balcones fault zone, which is located one-half mile west of and parallel to the west boundary of the Bell Gin quadrangle.

The lowest elevation in the area is 600 feet along the San Gabriel

River, two miles northeast of Georgetown; the maximum is 863 feet at the top of Rabbit Hill in the southwestern part of the area.

On the west, the quadrangle is characterized by a narrow belt of Comanche rocks which is one mile to one-half mile in width. This belt represents the eastern most boundary of the Grand Prairie subprovince and includes the Georgetown, Grayson, and Buda formations, which formations form a nearly level plain. This plain would be wider if the rocks forming it were not partially faulted out in this quadrangle. Gentle slopes of erosion valleys cut into or through the strata supporting the dip slope of the plain. A prominent west facing, northeast-southwest trending escarpment forms the eastern boundary of the Grand Prairie subprovince. This topographic feature is rarely more than 80 feet high, except near the San Gabriel River. This escarpment is capped by the very resistant Buda limestone and underlain by the Grayson marl. A characteristic steep scarp slope results from the weathering of the softer Grayson marl. The Buda usually presents a fairly flat dip-slope surface (1°-2°) to the southeast. At the foot of this escarpment, especially near the San Gabriel River, is an accumulation of talus. Undercutting of the softer underlying material frequently allows landslide blocks of Buda limestone to slump from the upper portions of the escarpment.

The Black Prairie subprovince owes its name to the deep black pedocal soils which cover it. This subprovince covers most of the area, and has been further subdivided into the Eagle Ford and White Rock Prairies, the

former referring to the characteristic physiographic features of the Eagle Ford formation, and the latter to those of the Austin Chalk formation. Adjacent to the Grand Prairie and having a northeast-southwest trend and dipping gently (1°) to the southeast is the Eagle Ford Prairie which is of varying width, the width rarely exceeding a mile and a half; it is underlain by the Buda limestone. Its soils are the residuum of shales and clays and represent the most productive agricultural soil in the area. In the eastern part of the area, the White Rock Prairie takes its name from the color of the underlying Austin Chalk formation. Its surface is more rugged than the Eagle Ford Prairie to the west; it is more sharply incised by deep stream channels and forms no steep bluffs and scarps like those in the Grand Prairie subprovince. Precipitous bluffs may occasionally occur along a stream, but the limestones of the Austin Chalk usually tend to form rounded hills with gently sloping sides. Because of rapid erosion, the white limestone appears at the top of many hills while their base is covered with a mantle of black pedocal soil from four to seven feet thick.

The transportation of erosional products from the higher areas to the west, down the tributary valleys of the San Gabriel, creates an extensive alluvial flat of variable width along the San Gabriel River. The banks of this alluvial flat are almost vertical. The heterogeneous mass of pebbles and cobbles of flint, chert, and limestones unconformably transgresses across the Cretaceous beds. A second gravel terrace running parallel to the river and eventually merging with the lower alluvial flat is found in

the northwest corner of the quadrangle, north of the San Gabriel River and extending for one mile east of the Balcones escarpment. In the center of the area along the main tributary of the San Gabriel River, Manskee Branch, is an extensive, thin, fan-shaped mantle of gravels which are topographically higher and which are more eroded than the gravel terraces along the San Gabriel River; these gravels seem to be older than any stream terrace in the area and suggest early extensive flooding of the San Gabriel River. A small erosional remnant of gravels suggesting an early stream terrace of the San Gabriel River lies unconformably upon the Buda escarpment to the northwest of Manskee Branch where State Highway 104 crosses the Buda escarpment.

The drainage pattern of the area is controlled by the San Gabriel River, which is a consequent stream flowing from west to east through the northern part of the area. The major portion of the water originates in the northwestern part of Williamson County, because of the structural drainage of the Lower Cretaceous sands. As the stream flows down dip and crosses the Balcones escarpment a half-mile from the northwestern part of the area, it is reinforced by springs rising under hydrostatic pressure through fissures. In the San Gabriel Park, opposite Georgetown, are three beautiful springs from which several thousand gallons of water per hour flow directly into the San Gabriel River. Other springs, originating from joints, occur where the San Gabriel River crosses the Buda formation. In contrast to the very shallow channel created on the more resistant for-

mations, many deep pools are developed where the San Gabriel River crosses the nonresistant Del Rio and Eagle Ford formations. The San Gabriel River flows northeast and empties into the Brazos River, the latter flowing southeast into the Gulf of Mexico. Numerous intermittent streams originate in the high Buda escarpment, drain the east-central part of the area, and enter Smith Branch; the latter enters the San Gabriel River one mile east of Georgetown. In the central part of the area, Manskee Branch is controlled by structure in the Austin formation over which it flows eastward into the San Gabriel River. Most of the drainage from the south consists of intermittent streams flowing northeast into Manskee Branch.

The vegetation in the area is almost entirely row crops, such as cotton, corn, and barley, cultivated on the rolling hills and valleys. West of the area is a thick forest of oak, hickory, and cedar, ending almost abruptly at the Balcones escarpment, but a few isolated patches may be found overlying the Georgetown formation in the northwestern portion of the area. Along the banks of the large streams, where the soil is very humid, is a rich growth of ash, oak, pecan, elm, hackberry, sycamore, wild grape, and other woody and herbaceous vegetation indigenous to this area. The end of the Grand Prairie with its northwest facing escarpment is characterized by live oak and mesquite growing between joints and fractures in the limestone. Except for the banks of streams and the bases of small valleys, the entire area is an open prairie with occasional clumps of oak growing in very rich, black, calcareous soil developed on the Austin chalk.

STRATIGRAPHY

General. The geologic section represented in the Bell Gin quadrangle includes a sequence of rocks varying in age from the Cretaceous through the Recent. Both Lower and Upper Cretaceous limestones and marls are overlain by Quaternary deposits, the latter consisting of alluvial materials which vary according to their elevation. The complete geologic section is illustrated in Figure 2.

The original sediments in the area were deposited almost horizontally, but because of the elevation of the land to the north after deposition, all of the formations in the area have been slightly inclined to the southeast, to the Gulf of Mexico. The oldest Cretaceous formation exposed is the Georgetown limestone, which is 91 feet thick and forms the base of the Washita Group. The lower half of the formation consists of limestones that are hard, dense, and gray to brown; the upper part is much softer and less calcareous, consisting of alternating beds of limestones and marls. The Georgetown has been faulted down against the Edwards, and now outcrops as a narrow belt parallel and adjacent to the Balcones fault. In a recent publication Feray et al. (1949) illustrate the Georgetown formation at Round Rock, Texas, five miles south of the Bell Gin quadrangle, as being separated by a slight disconformity from the underlying Kiamichi, which is separated from the Edwards by a more pronounced disconformity.

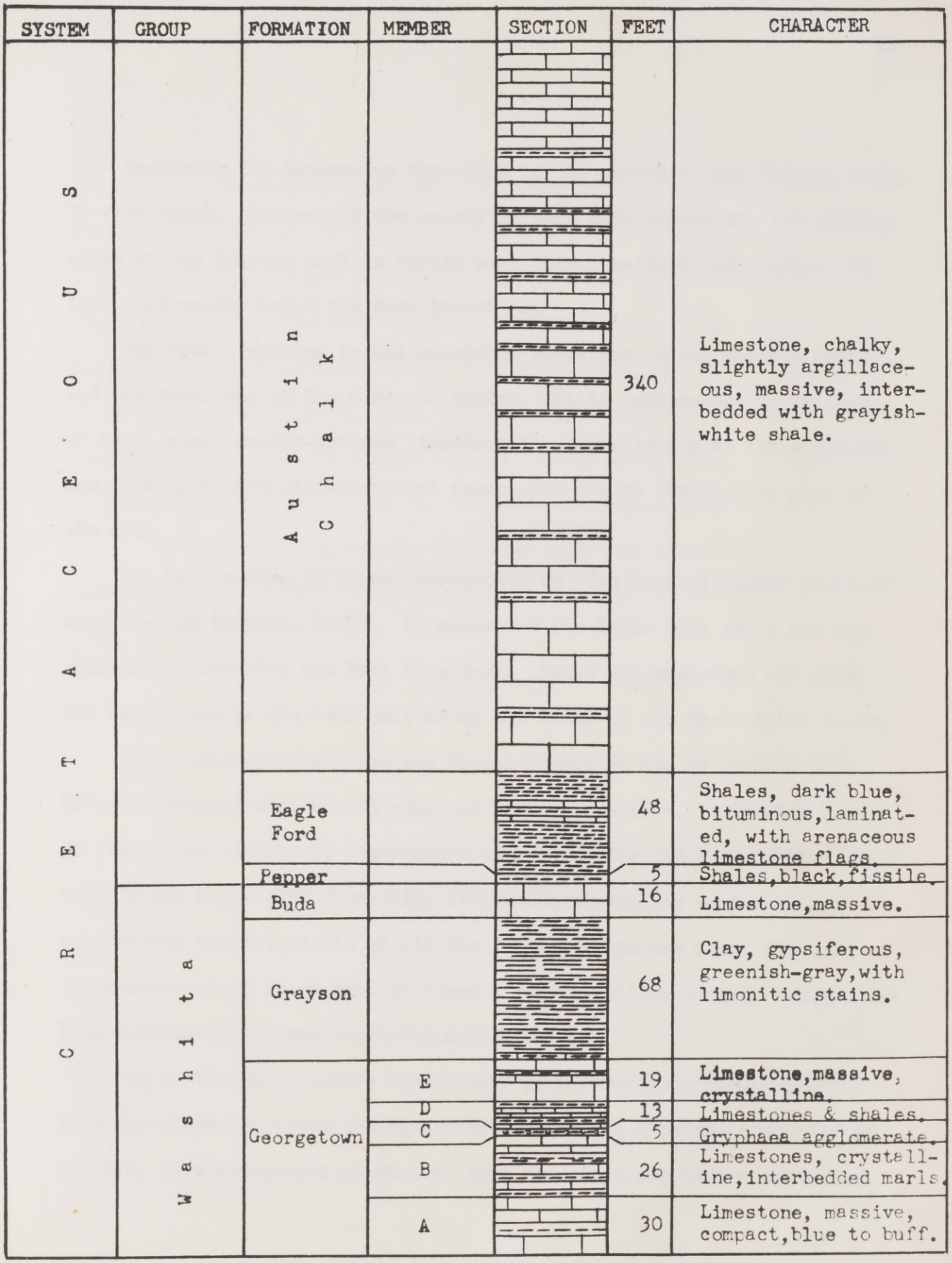


Figure 2.

COLUMNAR SECTION FOR BELL GIN QUADRANGLE

Overlying the Georgetown formation is the greenish gray Grayson marl, 70 feet thick. Because of the overlying hard Buda limestone, the outcrop width of the Grayson marl is rarely more than one-fourth of a mile. It lies conformably below the Buda limestone.

The Buda limestone is the uppermost formation of the Washita Group and the final bed of the Comanche series. It is represented by 16 feet of hard, pink, medium-grained limestone dipping slightly to the southeast and forming a northeast-southwest escarpment across the western part of the area.

The Gulf series is first represented by five feet of Pepper shale of Woodbine age (Adkins, 1932). It underlies the Eagle Ford shale and unconformably overlies the Buda limestone. Being non-resistant and thin, the Pepper can be observed only along the banks of the San Gabriel River.

Lying concordantly above the Pepper formation are 48 feet of dark blue, bituminous shales with numerous large, lens-like, lenticular bands of arenaceous limestone, interbedded with bentonite and yellow-brown shale. This is the Eagle Ford formation; it has the prevailing northeast-southwest strike characteristic of all the formations in the area. Because of its non-resistant character, it forms a gentle rolling prairie between the Buda escarpment and the overlying Austin Chalk.

The Austin Chalk covers almost half of the Bell Gin quadrangle and lies unconformably above the Eagle Ford shale. It consists primarily of massive, firm limestones which are light blue to cream before oxidation

and weather pure white. Its exact thickness is undeterminable because of faulting.

Overlying the Eagle Ford and Austin Chalk is a thin mantle of gravels which occur in the vicinity of Manskee Branch. The gravels consist predomantly of flint and constitute the Uvalde formation (Hill, 1901, p. 346) of Pleistocene age (Weeks, 1945, p. 1693). Along the banks of the San Gabriel River are still younger deposits of Quaternary age. These consist of pebbles of limestones, quartz, and rounded fragments of fossils; these form prominent terraces. Recent deposits have been brought down the San Gabriel River, chiefly during floods, and deposited as fluviatile material.

MESOZOIC ERA

In general the land areas of Texas were in an emergent condition at the beginning of the Mesozoic Era. No marine Triassic is known in Texas, and the only exposed marine Jurassic is in the Malone Mountains in southwestern part of Hudspeth County, Texas (Adkins, 1932).

CRETACEOUS SYSTEM

Adkins (1932, p. 259) states that this system represents the last great epicontinental marine invasion. It was probably deposited over most of Texas, and its remaining outcrops cover nearly one-third of the state.

Comanche Series

This series represents the entire "Lower Cretaceous" of the central Texas outcrop, and is represented by the Trinity, Fredericksburg, and Washita Groups. Although Trinity and Fredericksburg Groups are not observable in the area, their outcrops, and regional dip to the west along with well records at Georgetown prove that representatives of these groups are present at depth.

Washita Group

This group was named by Hill (1901, p. 118) for rocks from which he made various collections in the vicinity of Fort Washita, Bryan County, Oklahoma. It lies concordantly upon the Fredericksburg, and is composed of the following formations:

Bell Gin Section	Northeast Texas
Buda	
	- - - - - - - - - -
Grayson	Grayson
	Main Street
	Pawpaw
Georgetown	Weno
	Denton
	Fort Worth
	Duck Creek

Georgetown Formation.— This formation was named after the town of Georgetown, Texas, by R. T. Hill (1901, p. 72). Excellent exposures are present opposite the town of Georgetown on the San Gabriel River. Prior to the usage of the term Georgetown, it was called the Fort Worth limestone by

Hill and Vaughan (1898, p. 235) because of its similarity to the Fort Worth formation. The change in the name became necessary when it was discovered that the "Fort Worth limestone" represented a consolidation of North Texas formations and not solely the southern extension of the Fort Worth formation.

In North Central Texas, as far south as the Brazos River in McLennan County, Texas, the Duck Creek, Fort Worth, Denton, Weno, Pawpaw, and Main Street formations dip gently to the southeast at the rate of 40 feet per mile. South of the Brazos, the above formations are thinner and appear to be conformable. They seem to represent a period of continuous deposition. The name, Georgetown, has been applied to the continuation of this succession of rocks (excluding the Pawpaw, which pinches out) south of the Brazos River. Adkins (1932, p. 380) states the Pawpaw pinches out at Riovista, Texas, 60 miles south of Fort Worth, Texas. The Georgetown formation has an aerial distribution in the Bell Gin quadrangle of five square miles, and is 91.2 feet thick, approximately one-fourth the total thickness of its equivalents in Cooke or Grayson County (Cuyler, 1929).

The writer has been able to differentiate members of the Georgetown formation on the bases of paleontology and lithology. The formation is usually treated as a complete unit by most authors, but Adkins and Arick (1930) found it was composed of mappable units in Bell County, Texas.

Member A.— The oldest member of the Georgetown formation is of Duck Creek age. Paleontological horizons found in this member are almost iden-

tical with those of the Duck Creek formation of North Central Texas.

The topography of the member is essentially a level plain in northern Williamson County, but at Georgetown the member is usually found at the base of erosional valleys, being exposed along the banks of the San Gabriel River.

In the northern part of the Bell Gin quadrangle scattered patches of oak, cedar, and hickory may be found growing on the level plains littered with limestone fragments. Rarely does the soil of this member become very thick except where fluviatile material has covered the limestone beds forming a thin mantle of silt, mud, and clay.

Limestones which are crystalline, massive, compact, slightly chalky, light blue to buff, weathering yellow-white, alternating with thin beds of blue-gray, calcareous shales are very characteristic of this member. In the harder limestone beds concretions of pyrite are common. Weathering of these concretions to limonite gives the yellow color to the limestone.

In McLennan County, Texas, south of the Brazos River, the members of the Georgetown formation have not been differentiated into mappable units, but in adjacent Bell County, Adkins and Arick (1930, p. 41) state that the Duck Creek member outcrops east of and parallel to the Balcones fault as a narrow belt three-quarters of a mile wide. This narrow belt continues south into Williamson County, and its eastern boundary extends 260 yards into the Bell Gin quadrangle along the San Gabriel River.

One of the best paleontological markers in the Washita Group is found in the basal Duck Creek. This is Hamites comanchensis Adkins and Winton. This species was found at the base of Member A on the North Fork of the San Gabriel River, but because of proximity of this locality to the Balcones fault the bed could not be correlated with the measured section on the South Fork of the San Gabriel River. Although the zone of Hamites comanchensis Adkins and Winton is usually found below the Desmoceras brazoense (Shumard) zone, Hamites comanchensis Adkins and Winton may occasionally occur above the Desmoceras brazoense (Shumard) zone. Holaster simplex Shumard which occurs in the Duck Creek, Fort Worth, and Weno formations of North Central Texas was also found on the North Fork of the San Gabriel River. Desmoceras brazoense (Shumard) is also a good horizon marker for the basal portion of the Duck Creek formation, and in this area occurs at the base of Member A, chiefly in a massive, buff, chalky limestone. Above this horizon is another zone of ammonites which is not as abundant as the underlying zone, but is restricted to the upper part of the member. This is the Mortoniceras trinodosa (Böse) zone. Another zone which deserves mention is that of Mortoniceras leonensis (Conrad) which is restricted to the upper part of Member A in the Bell Gin quadrangle. Other forms present but not restricted to a particular portion of Member A are Gryphaea washitaensis Hill, Neithea georgetownensis Kniker, Lima wacoensis Roemer, and Cymatoceras texanum (Shumard).

The basal member of the Georgetown formation has a total thickness of 29.3 feet and is underlain by beds of Kiamichi age, the latter faulted out in the Bell Gin quadrangle. On May 25, 1950, the writer received the following communique from Dr. Keith Young:

> Certain fossils, including Oxytropidoceras belknapi (Marcou) have been brought to me by Mr. D. L. Ward. Mr. Ward states that he collected these fossils 50 yards west from the intersection of the North and South Forks of the San Gabriel River on the South Fork. The fossils were found in place and certainly indicate the presence of rocks of Kiamichi age at this locality.

The writer made a detailed section of Member A in the above locality prior to the above discovery, and although no Oxytropidoceras belknapi (Marcou) were found, further work in this locality may reveal that Beds 1 and 2 with a total thickness of two feet are of Kiamichi age and not of Duck Creek age. The top of Bed 2 is covered with many solution cavities which penetrate downward three or four inches. Many of these cavities are filled with calcite while the majority are interconnected and form weird intermingling channels. These cavities may have been formed by percolating waters from the overlying gravels (about ten feet thick), or they may represent the erosional break between Georgetown and Kiamichi deposition. The writer mapped these beds as part of Member A because they are lithologically similar to overlying strata. The lithological differentiation between the Kiamichi and the basal Georgetown is transitional as reported by Hill (1901, p. 256). According to Feray et al. (1949) the Kiamichi on Brushy Creek, Round Rock, Texas, consists of a dark gray,

nodular limestone and interbedded marls containing Exogyra plexa Cragin, Oxytropidoceras supani (Lasswitz), Oxytropidoceras trinitense (Gabb), and Oxytropidoceras belknapi (Marcou).

On the bases of previous work by Adkins and Arick (1930, p. 41) and Cuyler (1929, p. 1297) in counties adjacent to Williamson County, Member A is probably equivalent to the Duck Creek member of the Georgetown formation of these authors. Paleontological zonation is identical with their Duck Creek member and also similar to the Duck Creek formation of North Central Texas, although the zones are greatly condensed.

Excellent exposures may be found along the San Gabriel River in Georgetown, Texas, opposite the San Gabriel Park (Plate III.).

Member B.-- Paleontological horizons and lithology of this member are similar to those of the Fort Worth formation of northern Texas. It is understandable why the present Georgetown formation was, at one time, called the Fort Worth limestone by Hill (1898, p. 235).

This member is characterized by a chalky, compact, argillaceous, crystalline limestone, bluish-gray on fresh exposure, whitish on prolonged exposure. The lower limestone members are 12-14 inches thick, while those at the top become thinner and are interbedded with a blue-gray marl. Small particles of pyrite are interbedded in the lower half, but absent in the upper part of the member.

Probably the best paleontological marker for this member is Prohysteroceras austinense (Lasswitz), (Plate X, Fig. 2.), which occurs prin-

Plate III

Outcrop of Member A of the Georgetown formation in the banks of the San Gabriel River, opposite the San Gabriel Park, Georgetown, Texas.

cipally in the basal portion of the member and occasionally in the middle. Mortoniceras maxima (Lasswitz) and Mortoniceras kiliani (Lasswitz) (Plate X, Fig. 1.) occur above the Prohysteroceras austinense (Lasswitz) zone. Kingina wacoensis (Roemer) has been reported in the basal Kiamichi by Feray et al. (1949), and according to Adkins (1928, p. 80) it is very prolific at the top of the Georgetown formation over wide areas. In the Bell Gin quadrangle Kingina wacoensis forms a prominent zone because of its abundance in and restriction to a single bed in Member B. Forms that occur throughout this member are Gryphaea washitaensis Hill, Alectryonia carinata Lamarck, Macraster elegans (Shumard), Exogyra walkeri White, Ostrea subovata Shumard, Neithea georgetownensis Kniker, and Neithea wrighti (Shumard) (Plate XI, Fig. 2.).

Member B is 26.2 feet thick and is overlain conformably by a shell agglomerate of Gryphaea washitaensis Hill. The writer separated Members B and C on the extreme abundance of Gryphaea washitaensis Hill in Member C. The basal contact of Member B is not exposed.

In 1930 Adkins and Arick (p. 43) mapped the Fort Worth member of the Georgetown formation across Bell County and previously Cuyler (1929, p. 1297) had differentiated the Fort Worth as a distinct unit of the Georgetown formation in Travis County. In the Bell Gin quadrangle the paleontological zones of Member B are identical to those of the Fort Worth member of these authors and this member is probably equivalent to their Fort Worth member of the Georgetown formation.

A complete section is exposed along the San Gabriel River one-half mile northeast of Georgetown; while along the river between the farm of Leon Parriraz and the intersection of Smith Branch and the San Gabriel River is an excellent exposure of the upper part of this member. Plate IV, A. illustrates a typical outcrop of the Fort Worth formation at Sycamore Park, opposite the Liberty Stables, Fort Worth, Texas. Plate IV, B. shows Member B along the San Gabriel River.

Member C-- The shell agglomerate of Gryphaea washitaensis Hill forming this member is a convenient marker for locating the center of the Georgetown formation in the Bell Gin quadrangle.

Member C is distributed throughout the northwestern part of the area as a thin shell agglomerate overlying Member B. The member forms a flat surface and is nearly always covered by a thin mantle of gravels. It outcrops only along the banks of the river and streams where Andropogan grasses and oaks form the only type of vegetation (Plate V, A.).

The lithology of this member is essentially a Gryphaea agglomerate in a yellow-brown, marly matrix with a few insignificant layers of buff, argillaceous limestones containing Alectryonia carinata (Lamarck) and Neithea georgetownensis Kniker. The most remarkable of all specimens in the area was a complete Leiocidaris hemigranosus (Shumard) found beneath the bridge across Smith Branch, east of the I. O. O. F. cemetery, Georgetown, Texas. This locality is at the base of Member C, and the fossil (Plate XI, Fig. 1.) was found by Tom McAfferty of Georgetown, Texas.

Plate IV

A. Outcrop of Fort Worth formation at Sycamore Park, Fort Worth, Texas.

B. Outcrop of Member B of the Georgetown formation along the San Gabriel River, one-half mile northeast of Georgetown, Texas (Locality 2.).

Lying conformably above the five feet of Gryphaea shell aggregate is Member D which consists of alternating beds of argillaceous limestones and marls.

Member C is paleontologically and lithologically similar to the Denton member of Bell (Adkins and Arick, 1930) and Travis County (Cuyler, 1929). It probably represents a facies change of the Denton formation of northern Texas. Plate V, B. shows the typical Gryphaea agglomerate at the top of the Denton formation with the overlying limestone bed representing the base of the Weno formation at Sycamore Creek, Fort Worth, Texas.

Excellent exposures of Member C may be found east of Georgetown on Smith Branch, and at the top of the precipitous bluff one-half mile northeast of Georgetown on the San Gabriel River.

Member D -- The characteristic lithologic features of this member consist of thin-bedded, soft, argillaceous, gray to light blue limestones. Because this member is non-resistant, its distribution is largely controlled by the overlying, hard, massive limestone member. It is thus restricted in its lateral distribution to slopes of erosional valleys in the northwestern part of the area. Vegetation is absent due to the vertical slope of the outcrop.

The writer mapped this member mainly on its lithologic characteristics since practically no fossils were collected because the outcrops occur principally along the tops of precipitous bluffs. A variety of

Plate V

A. Andropogan grasses and oaks upon Member C of the Georgetown formation, Smith Branch, one-half mile east of Georgetown, Texas.

B. Gryphaea agglomerate at top of Denton formation, Sycamore Creek, Fort Worth, Texas.

Mortoniceras wintoni (Adkins) was the only fossil collected. In 1929 Cuyler (p. 1297) investigated this member along the San Gabriel and found the following fossils:

Trigonia clavigigera Cragin
Neithea georgetownensis Kniker
Cymatoceras texanus (Shumard)
Mortoniceras wintoni (Adkins)

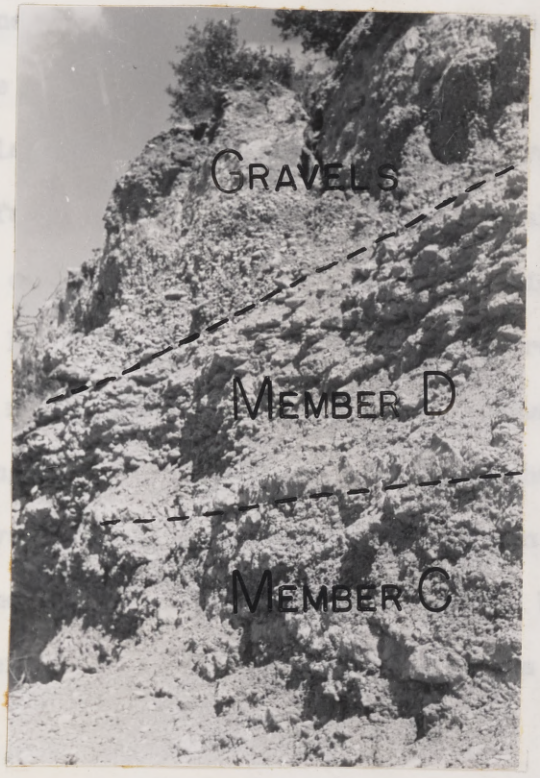
Although there appears to be no southern equivalent of the Pawpaw formation in this area, the upper contact of Member D is overlain conformably by the massive, crystalline, slightly chalky limestone of Member E. The writer was able to investigate this contact only along Smith Branch near Locality 5; it outcrops some 14 feet above Smith Branch near the top of a precipitous bluff. Due to the apparent absence of a Pawpaw equivalent, this contact merits further consideration in areas south of the Brazos River. Total thickness of this member is 12.6 feet.

On the basis of the fauna found by Cuyler, and because of the typical sequence of alternating limestones and marls characteristic of the Weno formation (Plate VI.) Member D is probably the southern equivalent of the Weno formation, and equivalent to the Weno member of the Georgetown formation in Bell County (Adkins and Arick, 1930, p. 45).

Northeast of Georgetown along a precipitous bluff overlooking the San Gabriel is a complete section of Member D. A more accessible locality is on Smith Branch, approximately 500 yards northeast of W. Whitley's farm.

Member E -- This member forms the top of the Georgetown formation,

Plate VI



Outcrop of Member D and C of Georgetown formation along the San Gabriel River, one-half mile northeast of Georgetown, Texas (Locality 2).

and is different from the underlying members in that it thins to the north instead of to the south.

Locally it has the largest outcrop area of any Georgetown member because of the massiveness and hardness of the limestone beds. It enters the quadrangle on the north as a belt two miles wide, its dip slope forming almost a level plain with a northeast-southwest trend. South of Georgetown this member is faulted out in part against the Balcones fault, exposing only a narrow outcrop of a few hundred yards width.

Adjacent to the Buda escarpment Member E is covered with a thick mantle of greenish-gray marly soil derived by creep and wash from the steep Grayson slopes. Along the river fluviatile deposits have spread a thin mantle of silts, clays, and muds over this member. In the northwest corner of the area the member forms a level plain capped by a hard limestone bed supporting scattered patches of oaks and sycamores surrounded by Andropogan grasses.

Member E is harder and more crystalline than any of the other members of the formation. The basal portion is a massive, hard, slightly chalky, crystalline limestone stained by limonite. The upper part is interbedded with thin beds of shale, but capped by a massive limestone bed lithologically similar to the basal limestone.

At the base of the member were found an abundance of Pachymya austinensis Shumard and one specimen of Alectryonia carinata (Lamarck). Turrilites brazoensis Shumard ranges from just above the base to almost the

top of the member. Homomya washita Cragin occurs occasionally. Kingina wacoensis (Roemer) was most abundant at the base, and Exogyra arietina Roemer most abundant at the top. Occasionally Kingina was found ranging to the top of the member and occurring with Exogyra arietina Roemer.

The total thickness of this member is 18 feet; it is conformably overlain by 65 to 75 feet of gray-greenish marl containing numerous cyrstals of gypsum. The hard, crystalline, underlying limestone of Member E grades upward into a clayey limestone forming the base of the Grayson formation.

On the bases of lithological and paleontological evidence, this member is equivalent to the Main Street member of the Georgetown formation. The abundance of Kingina wacoensis (Roemer) and Exogyra arietina Roemer as definite horizons embedded in a much harder, crystalline limestone is analogous in all respects to the Main Street member in Bell County (Adkins and Arick, 1930).

Extensive exposures may be found along the north bank of the San Gabriel River, one and two miles east of Georgetown. A complete section is exposed at the juncture of Smith Branch and the San Gabriel River.

Grayson Formation. -- This formation outcrops in a strip 50 yards to one-fourth mile wide. This non-resistant formation is restricted by the hard overlying Buda limestone to a narrow outcrop parallel to the Buda escarpment. It enters the area on the north, and because of its northeast-southwest trend, outcrops only a few hundred yards from the Balcones

fault south of Georgetown, Texas. Because it is non-resistant, many small erosional valleys are created by the subsequent streams originating at the top of the Buda. Vegetation is scarce because of the steep sloping surface and the poorly developed soils.

Lithologically the formation is characterized at the base by a yellow-brown clayey limestone overlain by a greenish-gray, gypsiferous marl with numerous limonitic stains derived from pyrite concretions. The sulphur of the pyrite combines with the calcium carbonate in the marl to form gypsum. Crystals of selenite occur in abundance on the surface. The upper one-third of the formation consists of brownish-gray marl; the upper 1.5 feet is very chalky.

Exogyra arietina Roemer is diagnostic of the lower 45 feet, occurring in great abundance. Gryphaea graysonana Stanton predominates in the upper one-third where Exogyra arietina Roemer is conspicuously absent. Mortoniceras n. sp. was found in the upper one-third of the formation.

The tendency of this formation to increase in thickness from north to south is evident in the area. From a thickness of 64.8 feet along the San Gabriel River the formation increases to 73.6 feet east of Georgetown and to 75 feet one and one-half miles south of Georgetown. Lying conformably above the Grayson is a thin-bedded Gryphaea graysonana Stanton agglomerate embedded in a pink chert and overlain by a very massive, pink, cherty limestone with numerous calcite streaks, this limestone weathers to a dark grayish-black. Below the Gryphaea agglomerate, the typical Grayson lithol-

ogy prevails except for the upper 18 inches in which the clay becomes almost a pure chalk because of weathering of the overlying Buda limestone.

The Grayson formation forms the high bluffs of the south bank of the San Gabriel River, two and three miles northeast of Georgetown. Its outcrop in the base of the river is partially hidden by Katy Lake, formed by the dam at the old Town's Mill.

Buda limestone.-- The Buda limestone forms the uppermost subdivision of the Washita division and the final unit of the Comanche series.

The Buda outcrops in the area as a narrow belt between the Grayson and Eagle Ford formations. It first enters the quadrangle at the San Gabriel River east of Katy Lake. From the river bed it swings to the southwest as a low bench forming the crest of the escarpment extending from two miles northeast to three miles south of Georgetown.

The formation can easily be traced on the basis of its vegetation. It usually supports a continuous growth of live oak (Quercus virginiana) which find a foothold in the limestone crevices. Other vegetation characteristic of this outcrop is prickly pear and agarita (Berberis fremontii).

Lithologically the formation consists of a pink cherty limestone with massive beds, five to six feet thick, which contain numerous calcite streaks; the limestone weathers to a dark grayish-black. The base is characterized by a Gryphaea graysonana Stanton agglomerate embedded

in a pink cherty matrix. Because of the hardness of the formation, complete specimens of fossils are difficult to obtain.

The following specimens were observed on the Hall ranch one mile east of Georgetown:

Nerinea volana Cragin

Budaiceras sp.

Neithea roemeri (Hill)

Turritella budaensis Shattuck

Tylostoma shumardi Whitney

The Gryphaea agglomerate at the base of the Buda was included in this formation mainly on its lithologic similarity to the overlying cherty limestone, and because Gryphaea graysonana Stanton, formerly called Gryphaea mucronata Gabb, has been described by Adkins (1928, p. 108) as being present at the base of the Buda and top of the Grayson. A complete section with a total thickness of 16 feet is exposed at the Hall ranch one mile east of Georgetown; two and one-half miles farther south the formation has increased in thickness and is represented by 19 feet of massively-bedded, pink, cherty limestone with a distinct absence of Gryphaea agglomerate at the base. At the latter outcrop the massively-bedded limestone lies horizontally upon the yellowish chalky clay of the Grayson formation.

Buda limestone is exposed in the bed of the San Gabriel River for one mile below the old Town's Mill as a series of faulted blocks, each dipping gently to the southeast. Opposite Alvin G. Domel's farm, Locality 7, the

dip increases to 3½ degrees, and the Buda disappears below the San Gabriel River; it underlies the Eagle Ford shale. A complete section is exposed along the escarpment on Hall's ranch, one mile east of Georgetown. The top of the formation is continuously exposed as a narrow bench forming the crest of the west facing escarpment that extends southwest-northeast across the Bell Gin quadrangle. The Buda-Grayson contact is excellently exposed 100 yards west of M. F. Phillip's farm, Locality 5.

Gulf Series

This series represents the "Upper Cretaceous" of Texas and includes the Pepper, Eagle Ford, Austin Chalk, Taylor, and Navarro formations. All are present in the Bell Gin quadrangle except the Taylor and Navarro formations, which outcrop southeast of the quadrangle in eastern Williamson County.

Pepper Formation.-- This formation is correlated with the upper subdivision of the Woodbine Group (Lozo, 1948) which is the first unit of the Gulf series. It is characterized by a very black non-calcareous, fissile, unctuous shale containing scattered crystals of selenite. The shale becomes bluish-purple upon exposure. It may be distinguished from the overlying Eagle Ford shale by the presence of selenite, its greater plasticity when wet, and its grain size which approximates that of clay as compared with the silt size grain of the Eagle Ford shales.

The Pepper-Eagle Ford contact is rather sharp. The fissile, black, gypsiferous shale of the Pepper ends abruptly and is overlain disconform-

ably by a bluish-black, calcareous, laminated shale containing three to six millimeter quartz pebbles. The Pepper is more thinly bedded than the overlying laminated shales of the Eagle Ford. The Pepper-Eagle Ford contact was observed in a trench five feet deep which had been cut into the east bank of the San Gabriel River below the Alvin G. Domel farm, Locality 7. The contact was 3.5 feet below the surface of the bank, and 14 feet from the river. The Buda-Pepper contact was not observed due to the seepage of water from a partially buried septic tank. Total thickness of the formation at this locality is ± 48 inches. Being non-resistant and thin, the Pepper is easily eroded from under the Eagle Ford and does not outcrop in the Bell Gin quadrangle because of subsequent slumping of talus from the overlying beds.

The formation has its type section in a tributary of Pepper Creek, Bell County, Texas, 37 miles north of the Bell Gin quadrangle. Alfred Loeblich (1946, p. 130) has described the fauna from this locality, and Mrs. Helen Plummer (Adkins, 1932, p. 419) of the Bureau of Economic Geology has described 40 inches of Pepper from Bouldin Creek, Austin, Texas. Lithologically, the author has compared the 40 inches of Pepper at Bouldin Creek, Austin, Texas, with that occurring in the Bell Gin quadrangle and has found them to be identical.

Eagle Ford shale.— This formation was first observed and described by Ferdinand Roemer (1852), but it was not until 1887 that R. T. Hill (p. 298) gave it the name Eagle Ford from its occurrence at Eagle Ford, Dallas Coun-

ty, Texas.

This formation outcrops as an irregular belt, lying east of and parallel to the Balcones fault in a north-south direction across the state of Texas. Like the Pepper formation, it has its greatest development farther north and gradually thins to the south. Unlike the latter, its extent is continuous across the state. The Eagle Ford outcrop, trending north-south and averaging less than a mile in width, enters the northeast corner of the Bell Gin quadrangle and, upon crossing the San Gabriel River, develops a northeast-southwest trend parallel to and capping the Buda escarpment.

Because of its non-resistant character and its gentle dip to the southeast it forms a gentle slope to the edge of the Austin Chalk; although a few rolling hills near the eastern limits of its outcrop indicate the stratigraphic interval containing limestone flags near the top of the formation.

The Eagle Ford soils are principally reddish-brown to black, soft, and rich in lime and potash, and form the most productive belt in the quadrangle. The vegetation is characteristic of soft formations in which the abundant woody plants are mesquites and a few hackberries. Rarely do any other woody plants grow on the Eagle Ford.

The Eagle Ford may be divided lithologically into three separate divisions comprising the basal, middle, and upper protions. First, the base is characterized by a soft, laminated, bituminous shale, black when

fresh and bluish-gray when weathered, containing numerous woody particles and limestone concretions averaging 15 inches in diameter. The top of the basal zone is marked by several one or two inch layers of bentonite weathering yellow-brown. The second or middle zone is represented by an alternating sequence of shales, limestones, and bentonite. The shales are thinly bedded, soft, petroliferous, black when fresh but weather yellow-brown, and the limestones are indurated, crystalline, yellow-brown, and slightly arenaceous. Above the limestone flags are the thin white bentonite beds weathering yellow-brown. The basal portion of the upper Eagle Ford is lithologically similar to the lower Eagle Ford, but the upper part shows a gradational change from black bituminous shale to yellow-brown marl.

The basal Eagle Ford is 29 feet thick with the top of the zone marked by numerous shark teeth. The middle zone, which includes the limestone flags, is 6.5 feet thick, and contains numerous Inoceramus labiatus Schlotheim and Inoceramus fragilis Hall and Meek. The upper Eagle Ford is 13 feet thick and is characterized by numerous Baculites gracilis Shumard (Locality 11) and Prionocyclus sp. Lasswitz (Locality 8). The total thickness of the Eagle Ford is 48.5 feet.

The typical yellow-brown marl of the Eagle Ford is overlain disconformably by massive, hard, fine-grained, chalky limestone comprising the basal Austin. At Locality 8 the top of the Eagle Ford consists of a black petroliferous shale with a high content of lime from the overlying chalky limestone.

Along the San Gabriel River, one mile below Katy Lake, 35 feet of basal and middle Eagle Ford form the high bluffs on the east side of the river. This is the only locality where the Eagle Ford-Pepper contact is exposed. The upper Eagle Ford including an excellent exposure of the Eagle Ford-Austin contact is exposed on the northeast corner of the quadrangle, one mile southwest of Weir, Texas, Locality 8. Other Eagle Ford-Austin contacts which are easily accessible are Locality 9, north of the Engdhl farm; Locality 10, 250 yards north of the Martin W. Bergstrom farm on Manskee Branch; and Locality 11, 50 yards southwest of the W. Johnson farm.

Austin Chalk Formation.-- This formation was first named "Austin limestone" in 1860 by B. F. Shumard (p. 583). It was not until 1890 however, when E. T. Dumble (p. 47) used the name "Austin Chalk", that the name was universally recognized. Prior to the usage of the term "Austin Chalk" the formation was called the "Dallas limestone" by Hill (1887, p. 298).

The Austin comprises the youngest Cretaceous formation in the area and covers 14 square miles of the quadrangle. It extends from the northeast corner of the quadrangle diagonally across the center of the area to the southwestern corner. It has a northeast-southwest trend and dips gently (1°) across the southwestern portion of the quadrangle.

The topography of the Austin is one of sharp contrast with the Eagle Ford. Its surface is more rugged and sharply incised by deep stream channels, yet forms no steep bluffs and scarps. Precipitous bluffs may occa-

sionally occur along a stream, but the limestones of the Austin Chalk usually tend to form rounded hills with gently sloping sides.

The pedocal soil formed on the Austin formation is usually a deep black, being derived from the tops of many limestone hills, and it supports an abundance of large live oaks. This species of oak, however, may also be found growing on the hard chalk with scattered clumps of mesquite and prickly pear. The occurrence of these large live oaks on the Austin is so characteristic that it may be used in identifying the formation in the field.

The lithologic character of the basal Austin consists of a light blue to cream, slightly argillaceous, chalky limestone which is massive and moderately soft, which weathers to a glaring white and contains numerous pyrite concretions. Occasionally interstratification of softer beds of shale also occur in the base. The middle of the formation is not quite as massively bedded, but there is a sharp increase in the number of shale beds. The top of the formation is not present in the quadrangle, but outcrops immediately to the southeast.

The exact thickness of the Austin in the Bell Gin quadrangle can not be determined because of faulting and because of the absence of a continuous outcrop perpendicular to the strike; on the basis of records from a water well drilled by Miles H. Richardson of Georgetown on the Snowden farm in the southeastern corner of the quadrangle, the Austin was found to have a thickness of ± 340 feet. Since the Austin dips southeast at 92 feet

per mile, and the width of the formation from the center of the quadrangle to the southeastern corner is 3.78 miles, its thickness, disregarding the possibility of faulting, should be 347 feet.

Evidences of channeling have been observed in the basal Austin Chalk of this quadrangle (Plate VII.). These channels are undoubtedly of submarine origin because of the presence of Inoceramus subquadratus Schlüter and Texanites americanus (Lasswitz), the uniformity in the bedding of the chalky limestone, and the relatively gentle banks formed by the channel (continental streams would more likely be evident by sharply incised channels). If these channels had been created by near shore tidal currents their trend would be southeast-northwest, which would be perpendicular to the prevailing strike; but in all cases they have an east-west trend indicating the greater probability of having been created by long-shore currents.

Zones of Austin Chalk

The naming of the various zones of the Austin has been based on a particular fossil from which the name of the zone has been derived. This certainly is not the only characteristic organism. In fact, a zone is actually identifiable by an assemblage of fossils of which the name-fossil is but one. All of the zones present in this quadrangle have been previously established by Marks (1950) with the exception of the Inoceramus undulatoplicatus Roemer zone which was established previously by Stephenson (1936a).

Plate VII

A. Channeling in the Austin Chalk 600 feet north of Locality 12, five miles east of Georgetown, Texas.

B. Channeling in the Austin Chalk 500 feet south of Locality 12, five miles east of Georgetown, Texas.

For many years the zone concept has been constantly revised and redefined until it has become vague and cumbersome. The need for simplification has led the author to adopt the following original definition of a zone concept as proposed by Albert Oppel (1856-1858):

> Zones are distinct horizons which through the constant and exclusive occurrence of certain species, mark themselves off from their neighbours.

Using the above concept as a basis, the author has divided and traced the following zones of the Austin formation across the Bell Gin quadrangle:

Exogyra ponderosa Roemer

Ostrea travisana Stephenson

Hemiaster texanus Roemer

Inoceramus undulatoplicatus Roemer

Gryphaea wratheri Stephenson

Inoceramus subquadratus Schlüter

Inoceramus subquadratus Schluter zone— Outcrop.— This zone is represented as a northeast-southwest belt averaging 2.5 miles in width and traversing diagonally across the center of the quadrangle. As its outcrop approaches the south-central boundary of the area it develops a north-south trend narrowing to one mile in width upon crossing the southern boundary. This zone comprises the base of the Austin formation and lies stratigraphically below the Gryphaea wratheri Stephenson zone. The total thickness is approximately 230 feet.

Lithology.— The lithology of this zone is light blue to cream, slightly argillaceous, massively bedded (beds two to ten feet thick), fairly soft, chalky limestone which weathers to a glaring white, contains numerous marcasite concretions, and is interstratified with soft beds of grayish-white shale.

Fossils.— Inoceramus subquadratus Schlüter occurs profusely in the basal part of the zone. It ranges from the base to the top of the zone becoming almost conspicously absent toward the top. Many of these species are two to two and a half feet long, occurring mainly in the eastern part of Manskee Branch, and further eastward along the San Gabriel River. Texanites americanus (Lasswitz) is restricted to this zone and is commonly associated with Inoceramus subquadratus Schlüter. Other fossils found were Spondylus guadalupae Roemer (Plate XI, Fig. 3), Parapuzosia americana Scott and Moore, and Durania austinensis (Roemer).

Exposures.— A typical outcrop of this zone may be found along the northeast-southwest intermittent stream in the vicinity of Locality 12.

Gryphaea wratheri Stephenson zone—Outcrop.—Lying east and parallel to the Inoceramus subquadratus Schlüter zone in the southeastern corner of the quadrangle is a narrow belt 600 feet wide and approximately 10.5 feet thick, comprising the Gryphaea wratheri Stephenson zone. This zone lies stratigraphically below the Inoceramus undulatoplicatus Roemer zone and above the Inoceramus subquadratus Schlüter zone.

Lithology.-- This zone is characterized by a light cream, massive, hard, chalky limestone weathering to a pure white and interbedded with beds of soft, grayish-white shale averaging one foot in thickness.

Fossils-- Gryphaea wratheri Stephenson occurs in great abundance in the chalky limestone with only a few scattered specimens present in the shale. No other fossil was found associated with the Gryphaea except a few Texanites sp.

Exposures.-- Excellent outcrops of this zone may be found at localites 13, 14, 15, and 16.

Inoceramus undulatoplicatus Roemer zone -- Outcrop.-- The outcrop of this zone enters the southeastern corner of the quadrangle and has average width of 1500 feet, gradually increasing in width as it crosses the area in a northeast-southwest trend, and crossing the southern boundary with a width of three-quarters of a mile. Stratigraphically this zone lies below the Hemiaster texanus Roemer zone and above the Gryphaea wratheri Stephenson zone. Its exact thickness has not been determined.

Lithology.-- In the eastern part of the area the limestone beds are buff to white, slightly crystalline, massive, chalky, and contain numerous marcasite concretions. Toward the southern boundary of the area, the buff to white limestone becomes yellow but still retains the rest of its lithologic character.

Fossils.-- No fossils other than two specimens of Inoceramus undulatoplicatus Roemer were found. The presence of this zone was determined

largely by the outcrop of the Hemiaster texanus Roemer zone above, and the Gryphaea wratheri Stephenson zone below.

Exposure.-- Locality 17.

Hemiaster texanus Roemer zone -- Outcrop.-- This zone enters the southeast corner of the quadrangle with an average width of 600 feet, which width gradually diminishes to 250 feet in a southwesterly direction. After three-quarters of a mile, the narrow outcrop develops a north-south trend across the southern boundary of the quadrangle. This change in trend is due to a topographic high in the southeast corner of the area. Stratigraphically this zone lies below the Ostrea travisana Stephenson zone and above the Inoceramus undulatoplicatus Roemer zone. The thickness of the zone varies from six to ten feet.

Lithology.-- The lithologic character of the zone is represented by a chalky, slightly crystalline, massively bedded, argillaceous limestone which is interbedded with grayish white, calcareous, laminated shale containing numerous limonitic stains.

Fossils.-- Hemiaster texanus Roemer occurs commonly, but not abundantly, in this zone. Associated with it are a few scattered specimens of Texanites texanum (Roemer).

Ostrea travisana Stephenson zone -- Outcrop and Lithology.-- This outcrop is very similar to the underlying Hemiaster zone in thickness, and width, and approaches it in lithology. The underlying massive, crys-

talline, argillaceous limestone has become yellow instead of white, and the color of the soil has changed from black to yellow-brown. Stratigraphically this zone lies below the Exogyra ponderosa Roemer zone.

Fossils.— Ostrea travisana Stephenson is rare in the quadrangle, but occasionally is associated with Hemiaster texanus which may occur above its own zone.

Exposure.— This zone outcrops along the top of the hill east of and overlooking Locality 18.

Exogyra ponderosa Roemer zone —Outcrop and Lithology.— In the Bell Gin quadrangle only the basal portion of this zone outcrops at the top of the topographic high which forms the southeast corner of the quadrangle. The lithologic character is undeterminable due to the cultivation of the area. Stratigraphically this zone lies above the Ostrea travisana Stephenson zone and forms the top of the Austin Chalk in the Bell Gin quadrangle.

Fossils.— The determination of this zone was based on several Exogyra ponderosa Roemer which were exposed following cultivation. Lying stratigraphically below the Exogyras were hundreds of Gryphaea aucella Roemer which are useless in correlation because of their recurrence in the Austin formation.

Exposure.— The above fossils were best observed 1000 feet east of Locality 18.

QUATERNARY SYSTEM

Uvalde Gravels

These gravels have been deposited in the central part of the quadrangle, around Manskee Branch and their present elevation is 720 feet.

The gravels consist predominantly of flint cobbles and limestone nodules which were derived from the Edwards and other Lower Cretaceous limestones to the west.

Deussen (1924, p. 112) mapped these gravels in the quadrangle as the "Reynosa" formation; however, they had been called "Uvalde" by Hill (1901, p. 346). In 1945 Weeks (p. 1693) assigned the Uvalde to the middle Pleistocene which includes the highest terrace deposits in and adjacent to the Edwards Plateau. The author has followed Weeks' classification and assigned these gravels to the Uvalde.

Beaumont Terraces

These terraces outcrop along the banks of the San Gabriel River almost continuously from Georgetown to the eastern end of the quadrangle at an elevation of 650 to 600 feet.

Rounded pebbles of limestone, quartz, quartzite, and Lower Cretaceous fossils were found embedded in a matrix of reddish-brown soil forming the typical Beaumont (Sixth Street) terraces.

The following fossils were found:

Exogyra texana (Roemer)	Walnut and Comanche Peak
Gryphaea marcoui Hill and Vaughan	Walnut and Comanche Peak
Oxytropidoceras acutocarinatum (Shumard)	Walnut and Comanche Peak
Exogyra arietina Roemer	Del Rio
Protocardia texana (Conrad)	Washita Group

These gravel terraces have been designated by the author as being Beaumont (Sixth Street) in age, following Weeks' (1945, p. 1693) classification.

STRUCTURE

General. -- The Bell Gin quadrangle lies within the Grand Prairie and Black Prairie subprovinces of Texas and shares their geologic structure. The eastern most portion of the Grand Prairie subprovince lies in the western part of the quadrangle, and the western portion of the Black Prairie subprovince lies in the eastern part of the quadrangle. The Cretaceous and Quaternary beds of the quadrangle dip gently to the southeast, having been tilted in that direction after their deposition by the elevation of the land to the north and west. This has resulted in the oldest formations being exposed at a greater distance than the youngest from the Gulf of Mexico, the youngest formations being exposed closer to the coast, following the beveling of the surface of the land.

This quadrangle lies one-half mile east of and parallel to the north-south striking Balcones fault zone. This fault zone represents a zone of

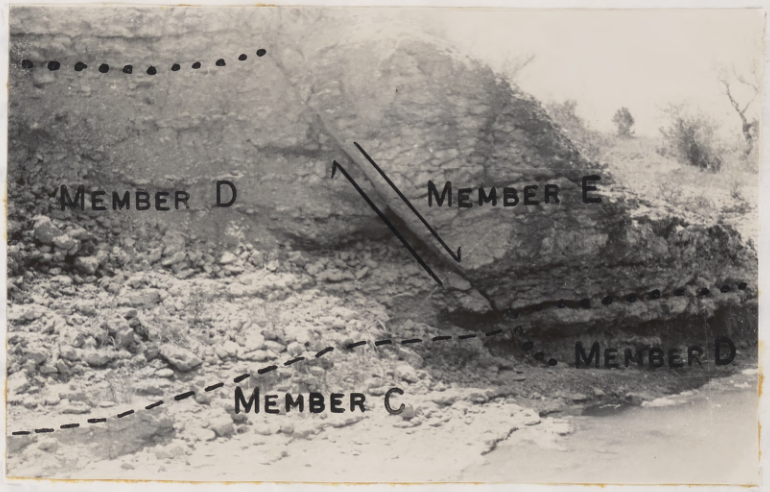
structural weakness, the eastern edge of which is manifested in the Bell Gin quadrangle by countless normal faults and joints. Records from a water well drilled in 1914 by the city of Georgetown indicate that the main Balcones fault, one-half mile west of the quadrangle, has a displacement of 96 feet at that locality with the downthrown side on the east.

In subsequent discussion, the term fault will be regarded by the author as being either major or minor. A minor fault may be defined as one having a displacement of less than four feet. A major fault is defined as one having a displacement of greater than four feet.

In the area between the Balcones fault zone and the Bell Gin quadrangle, numerous minor faults are exposed along the banks of the San Gabriel River. All of these faults are normal and parallel to the main Balcones fault. Their minor displacement indicates the intensity of the faulting was not severe immediately adjacent to the Balcones fault zone.

Bell Gin quadrangle.-- In the Bell Gin quadrangle the dips of the strata are mostly very gentle with an average dip of 92 feet per mile to the southeast. The average strike of the beds is N 45° E. Local faulting has affected the dip of the beds only in the immediate fault zone.

The largest faults in the area are situated along the bed of the San Gabriel River at Localities 2 and 3, one mile northeast of Georgetown. At Locality 2, calcite blocks nine to ten inches wide may be found along the bed of the San Gabriel River. The upthrown side of the fault, the fault-plane of which is determined only by the calcite blocks, is indicated



A. Major fault involving Members of Georgetown formation along Smith Branch, one mile east of Georgetown, Texas.

B. One of hundreds of minor faults along northeast-southwest intermittent stream near east-central boundary of quadrangle (Locality 12).

by the thirty-five foot bluff on the north side of the river, whereas the downthrown side is covered by an alluvial flat. At Locality 3, the northwest-southeast striking fault has controlled the course of the San Gabriel River. The fault plane is covered, but Member B of the Georgetown formation outcrops against Member E, indicating a displacement of 18 or more feet. Below Georgetown several minor faults striking in all directions and forming small grabens and horsts may be seen along the banks of the San Gabriel River.

A set of northeast-southwest trending joints accompanied by a few minor step-faults dipping in a southeasterly direction are exposed along the San Gabriel River opposite Locality 7. These joints are clearly associated with the step-faults.

Most of the faulting occurs in the east-central part of the quadrangle, in which locality hundreds of minor faults along with a few major faults control Manskee Branch. The author has estimated that three to four times as many faults occur in this part of the quadrangle as compared with the area adjacent to the Balcones fault zone; it seems, therefore, that because of some local disturbance, and partly because of the Balcones fault, this structure has been localized. Igneous intrusions could have caused this localization of structure although no evidences of such are present.

The faults in the Austin Chalk are Post-Austin in age. There is no evidence of Quaternary faulting in the Bell Gin quadrangle.

The apparent lack of structure in the southern part of the quadrangle is the result of cultivation producing a small number of exposed outcrops.

ECONOMIC GEOLOGY

The Bell Gin quadrangle is well supplied with certain natural resources which include the following:

Water.— Artesian water forms the main source of water in the quadrangle. Numerous artesian springs may be found along the San Gabriel River, especially in the San Gabriel Park opposite Georgetown and near Locality 7 where the San Gabriel River crosses the Buda limestone. Here the springs originate principally from joints in the limestone.

The water for the city of Georgetown and for commercial purposes can be derived only from the Trinity sands at an average depth of 1900 feet. Water for home consumption can usually be derived from a porous stratum near the top of the Edwards formation which underlies the Georgetown formation. Wells in the vicinity of Georgetown obtain water from the Edwards formation at a depth of 125 feet increasing to 600+ feet in the southeast corner of the quadrangle.

Oil and Gas.— No shows of oil and gas are known from this quadrangle; in 1931 John Bohman of Georgetown drilled a 2100-foot hole on his farm in the southwestern corner of the quadrangle, but no oil or gas were found. The well was abandoned a few feet below the Trinity reservoir.

Limestone.— Limestones from this quadrangle used for commercial purposes

occur in the following formations: Georgetown formation, Buda formation, and Austin Chalk. Locally the Georgetown and Buda are used for building purposes, but the small outcrops of Georgetown and the insignificant thickness of the Buda makes these limestones unsuitable for large scale quarrying.

The Austin Chalk outcrop occupies a wide, continuous band across the southeastern part of the quadrangle and is quite suitable for large-scale quarrying at most places accessible to railroads. In 1939 the basal Austin was quarried in the southwestern corner of the quadrangle and subsequently abandoned during the beginning of World War II for lack of profitable market. The stones derived from this quarry were usually impure and formed only a fair grade of building stone.

The Buda is hard and almost cherty and is used extensively by the railroads as crushed stone for ballast.

Many members of the Georgetown formation offer good combinations of raw material for Portland cement, but their availability limits this enterprise.

Clay.— The main clay formations in the quadrangle are the Grayson and the Eagle Ford. Tests have not been made on the Grayson formation to determine its value as fire or refractory clays. A fire clay must be able to endure high temperatures without much change other than loss of water. The Eagle Ford shales in North Central Texas have been used extensively in the manufacture of bricks, and there is no doubt that the shales in this area have

the same possibilities.

Gravels.— The presence of several gravel quarries in the Bell Gin quadrangle is evidence of rich gravel deposits. The majority of these quarries are located along the banks of the San Gabriel River near the town of Georgetown. In this vicinity the upland terraces are 20 + feet thick and are worked extensively for roads and for concrete aggregate.

In the central part of the area, thin deposits of gravels have been made available by the streams and by the San Gabriel River.

BIBLIOGRAPHY

ADKINS, W. S., 1928, Handbook of Texas Cretaceous Fossils: University of Texas Bulletin, 2838, pp. 1 - 303, pls. 2 - 35.

------- and ARICK, M. B., 1930, Geology of Bell County, Texas: University of Texas Bulletin, No. 3016, pp. 1 - 92.

------, 1932, The Geology of Texas, Vol. 1, Stratigraphy,-- Part 2, The Mesozoic Systems in Texas: University of Texas Bulletin, No. 3232, pp. 239 - 455.

CRAGIN, F. W., 1893, A contribution to the invertebrate Paleontology of the Texas Cretaceous: Texas Geological Survey, 4th Ann. Rept., p. 203.

CUYLER, ROBERT H., 1929, Georgetown formation of Central Texas and its Northern Texas equivalents: Amer. Assoc. of Petrol. Geol., Bull., Vol. 13, No. 10, pp. 1291 - 1299.

DEUSSEN, A., 1924, Geology of the Coastal Plain of Texas, west of Brazos River: U. S. Geological Survey Prof. Paper No. 126.

DUMBLE, E. T., 1890, Report of the State Geologist for 1899: Texas Geol. Survey First Ann. Rept., Pt. 1.

FENNEMAN, NEVIN M., 1938, Physiography of Eastern United States: McGraw-Hill, New York.

FERAY, DAN E., et al. 1949, Cretaceous of Austin, Texas Area: Shreveport Geol. Soc. Guide Book, 17th Ann. Field Trip, pp. 30 - 32.

HILL, R. T., 1887, The Topography and geology of the Cross Timbers and surrounding regions in northern Texas: Ann. Jour. Sci., Vol. 33.

----------, 1901, Geography and Geology of the Black and Grand Prairies, Texas: U. S. Geological Survey, 21st Ann. Rept., Pt. 7.

----------, and VAUGHAN, T. W., 1898, Geology of the Edwards Plateau and Rio Grande Plain adjacent to Austin and San Antonio, Texas: U. S. Geological Survey, 18th Ann. Rept., Pt. 2, pp. 193 - 321.

LASSWITZ, R., 1904, Die Kreide--Ammoniten von Texas: Geol. und Pal. Abh. (Koken) N. F., Bd 6, Heft 4, p. 252, pl. 8, fig. 1.

LOEBLICH, ALFRED R., JR. 1946, Foraminifera from the Type Pepper Shale of Texas: Jour. of Pal., Vol. 20, No. 2, pp. 130 - 139.

LOZO, FRANK E., 1948, Stratigraphic relationships of the outcrop Woodbine sand of northeast Texas: Geol. Soc. Amer., Bull., Vol. 59, pp. 1337 - 1338.

MARKS, EDWARD, 1950, Biostratigraphy of Jonah Quadrangle, Williamson County, Texas: University of Texas Thesis.

MOORE, R. C., 1948, Stratigraphical Paleontology: Geol. Soc. Amer., Bull., Vol. 59, pp. 301 - 326.

ROEMER, F., 1852, Die Kreidebildungen von Texas und ihre organischen Einschlusse: A. Marcus, Bonn.

SCOTT, G. and MOORE, M. A., 1928, Ammonites of enormous size from the Texas Cretaceous: Jour. of Pal., Vol. 2, pp. 273 - 279.

SHUMARD, B. F., 1860, Observations on the Cretaceous strata of Texas: Acad. Sci. St. Louis Trans., Vol. 1.

----------, 1863, On the discovery of dictyledonous leaves in the Cretaceous of Texas, and the existence of an extensive Miocene formation, equivalent to the Bone beds of the Mauvaises Terres of Nebraska: Ac. Sc. L., Tr. 2: 140 - 141.

STEPHENSON, L. W., 1927, Notes on the stratigraphy of the Upper Cretaceous formations of Texas and Arkansas: Amer. Assoc. of Petrol. Geol., Bull., Vol. 11, No. 1, pp. 1 - 17.

----------, 1930, Two new molluske of the Genera Ostrea and Exogyra from the Austin chalk, Texas: Proc. U. S. Natl. Mus., Vol. 76, Art. 18, pp. 2 - 4, pls. 1 - 3.

----------, 1936a, New Upper Cretaceous Ostreidas from the Gulf Coast: U. S. Geol. Sur. Prof. Paper No. 186a, pp. 2 - 4, pl. 1, figs. 1 - 4; pl. 2, fig. 5; pl. 3, figs. 1 - 5.

----------, 1936b, Stratigraphic relations of the Austin, and Equivalent formations in Texas: U. S. Geol. Surv. Prof. Paper No. 186g, pp. 133 - 146.

TAFF, J. A., 1892, Reports on the Cretaceous area north of the Colorado River: Texas Geol. Surv., Third Ann. Rept., pp. 247 - 321.

WEEKS, W., 1945, Quaternary deposits of Texas Coastal Plain between Brazos River and Rio Grande: Amer. Assoc. of Petrol. Geol., Bull., Vol. 29, p. 1693, map, fig. 1.

APPENDIX

DETAILED MEASURED SECTIONS

Base and middle of Eagle Ford measured along east bank of San Gabriel River opposite the Alvin G. Domel farm, Locality 7. Unit 3 of Eagle Ford measured one mile southwest of Weir, Texas, Locality 8.

Eagle Ford shale:

		Thickness
3.	Shale, bituminous, laminated, soft, black when fresh and bluish gray when weathered, calcareous; top 6 feet of unit shows graditional change from shale to yellow-brown marl, and contains numerous Baculites gracilis Shumard and Prionocyclus sp. Lasswitz	13.1'
2.	Limestone, beds 0.1-0.2 foot thick, indurated, gray when fresh and yellow-brown when weathered, slightly arenaceous, very crystalline, and interstratified with soft, petroliferous, black shale weathering yellow-brown and 0.1-0.2 foot beds of weathered yellow-brown bentonite; unit contains Inoceramus labiatus Schlotheim and Inoceramus fragilis Hall and Meek	6.5'
1.	Shale, bituminous, laminated, soft, black when fresh and bluish gray when weathered, calcareous, containing woody particles and limestone concretions averaging 1.2 feet in diameter. Base of unit marked by 3-6mm quartz pebbles, while the top of the unit has several 0.1-0.2 foot layers of bentonite weathering yellow-brown and containing numerous shark teeth	28.9'
	Total thickness of Eagle Ford shale =	48.5'

Section of Buda limestone and Grayson marl measured one mile east of Georgetown, Texas, on the Hall ranch, Locality 4.

Buda limestone:

		Thickness
2.	Limestone, massive, hard, pink or light brown when fresh and grayish-black on weathered surface, cherty, fine-grained, with upper 1.5 feet weathering into honeycomb structure; unit contains numerous calcite streaks, Nerinea volana Cragin, Budaiceras sp., Neithea roemeri (Hill), Turritella budaensis Shattuck, and Tylostoma shumardi Whitney	15.0'
1.	Gryphaea graysonana Stanton agglomerate, embedded in a pink, cherty limestone matrix	1.0'
	Total thickness of Buda =	16.0'

Grayson marl:

4.	Clay, chalky, white on fresh and light brown on weathered surface	1.5'
3.	Marl, gypsiferous, brownish-gray, containing numerous Gryphaea graysonana Stanton and Mortoniceras n. sp.	24.6'
2.	Marl, gypsiferous, greenish-gray, with numerous limonitic stains from pyrite concretions, containing numerous Exogyra arietina Roemer	44.3'
1.	Limestone, clayey, soft, white on fresh and yellow-brown on weathered surface, containing Kingina wacoensis (Roemer) and Exogyra arietina Roemer. Top of unit grades into overlying unit and base grades into hard, crystalline, fine-grained limestone of Georgetown formation	3.0'
	Total thickness of Grayson marl =	73.6'

Georgetown formation:

Section of Member E measured along east bank of San Gabriel River, one mile northeast of Georgetown, Texas. (Locality 3)

		Thickness
17.	Limestone, massive, hard, white on fresh and gray on weathered surface, slightly crystalline, chalky with limonitic stains	3.0'
16.	Limestone, beds 0.3-0.5 foot thick, indurated, buff on fresh and weathers yellow-brown, slightly crystalline, limonitic, and interstratified with 0.3-0.5 foot beds of chalky, limonitic stained shale	1.5'
15.	Limestone, massive, hard, crystalline, white when fresh. Top three feet honeycombed and weathers gray-black while lower six feet weathers light yellow-brown. Fresh samples adher to tongue. Kingina wacoensis (Roemer) occurs occasionally with Turrilites brazoensis Shumard	9.0'
14.	Limestone, massive, hard, yellow-brown when fresh and brown when weathered, slightly chalky at the base, crystalline, limonitic, with numerous Kingina wacoensis (Roemer). Turrilites brazoensis Shumard found three feet from base	5.5'
	Total Member E =	18.0'

Section of Members D, C, and B, measured at Locality 2, one mile northeast of Georgetown, Texas, on the north bank of San Gabriel River.

Member D:

13.	Limestone, massive, hard, buff when fresh and white on weathered surface, chalky, crystalline, fine-grained and containing numerous limonitic stains. Top eroded and overlain by thick deposit of gravels.	3.0'
12.	Limestone, beds 0.3-0.5 foot thick, indurated, light gray on fresh and white or yellow-brown on weathered surface, chalky, very crystalline,	

		Thickness
	fine to medium-grained, alternating with a tan on fresh and white on weathered surface, crystalline marl; unit contains Mortoniceras wintoni (Adkins) .	9.6'
	Total Member D =	12.6'
Member C:		
11.	Gryphaea washitaensis Hill agglomerate, embedded in 0.5-0.7 foot beds of yellow-brown, marly matrix which is interbedded with 0.5-0.9 foot beds of hard, white, fine-grained, crystalline limestone containing numerous limonitic stains	5.1'
	Total Member C =	5.1'
Member B:		
10.	Limestone, beds 0.3-0.4 foot thick, indurated to hard, gray on fresh and white on weathered surface, crystalline, chalky, medium to fine-grained, interbedded with 0.2-0.3 foot beds of soft, tan on fresh and yellow-brown on weathered surface, pyritic fissile shale; unit contains Macraster elegans (Shumard), Neithea georgetownensis Kniker Mortoniceras kiliani (Lasswitz), Gryphaea washitaensis Hill and several 0.2-0.5 foot zones of Exogyra walkeri White at the base. Top contains a 2.0 foot zone of Kingina wacoensis (Roemer) which marks the Member B-Member C contact .	7.9'
9.	Limestone, beds 1.0-1.2 foot thick, indurated, grayish white on fresh and bluish gray on weathered surface, slightly crystalline, chalky, medium to fine-grained, interbedded with 0.2-0.8 foot beds of grayish white marl; unit contains minute pyrite crystals, Macraster elegans (Shumard), Neithea bellula Cragin, Plicatula incongrua Conrad and Neithea texanus Roemer. Also, a 1.0 foot Exogyra walkeri White zone 2.8 feet from base and a 3.5 feet Gryphaea washitaensis Hill zone 4.3 feet above base	11.9'
. . . . .	Covered	4.5'
8.	Limestone, thin-bedded, indurated, light gray	

Thickness

on fresh and grayish blue and yellow-brown on weathered surface, crystalline, fine-grained, interbedded with a fissile, soft, gray on fresh and grayish blue on weathered surface, crystalline shale, with euhedral biotite crystals; unit contains Macraster elegans (Shumard), Prohysteroceras austinense (Lasswitz), Neithea texanus Roemer, and Neithea bellula Cragin . . . . 1.9'
Base of river consists of shaly limestone, indurated, light gray on fresh and grayish blue on weathered surface, crystalline, chalky, medium-grained, containing small particles of pyrite and Alectryonia carinata Lamarck.

Total Member B = 26.2'

Section of Member A measured along south bank of San Gabriel River opposite San Gabriel Park, Georgetown, Texas.

7. Limestone, massive, hard, cream on fresh and yellow-brown on weathered surface, crystalline, fine-grained, sublithographic, interbedded with gray on fresh and yellow-brown on weathered surface, fissile shale; unit contains a 4.0 feet Gryphaea washitaensis Hill zone at the top, plant stems, Neithea georgetownensis Kniker, Lima wacoensis Roemer, Mortoniceras leonensis (Conrad), Mortoniceras trinodosa (Boese), and Protocardia texana (Conrad) . . . . . 5.1'
6. Limestone, beds 1.0-3.0 feet thick; base, light gray on fresh and black on weathered surface; top of zone, cream on fresh and yellow-brown on weathered surface, crystalline, chalky, medium to fine-grained, interbedded with 0.4-0.8 foot beds of tan marl; unit contains Neithea texana Roemer, Gryphaea washitaensis Hill, Mortoniceras trinodosa (Boese) and Cymatoceras texanum (Shumard) . . . . . 12.5'
5. Limestone, beds 0.5-1.0 foot thick, indurated, cream on fresh and gray on weathered surface, crystalline, interbedded with 0.3-0.5 foot beds of soft, buff on fresh and white on weathered

		Thickness
	surface, crystalline, medium to fine-grained, chalky shale, containing a 1.5 foot zone of Gryphaea washitaensis Hill which is 1.5 foot above base and a 1.0 foot zone of Desmoceras brazoense Shumard 3.0 feet above base	7.5'
4.	Limestone, beds 0.2-0.3 foot thick, indurated, light gray on fresh and grayish-white on weathered surface, slightly crystalline, fine-grained, interbedded with a fissile, soft, buff on fresh and white on weathered surface, shaly chalk	1.5'
3.	Limestone, massive, indurated, light gray on fresh and grayish-brown on weathered surface, crystalline, chalky, medium to fine-grained, containing gastropods with crystallized shells, zone of Desmoceras brazoense Shumard, and Cardium sp.	1.0'
2.	Limestone, thin-bedded, indurated to hard, light gray on fresh and purplish-red on weathered surface, slightly crystalline, fine-grained, weathering into honeycomb structure which forms weird patterns on upper surface	0.3'
1.	Limestone, massive, indurated, cream on fresh and buff on weathered surface, chalky, medium-grained; unit contains Neithea texana Roemer, crystals of calcite and pyrite, and circular solution pits filled with secondary calcium	1.4'
	Total Member A =	29.3'
	Total thickness of Georgetown formation =	91.2'

Explanation of Plate IX.

All figures x 1

Fig. 1. Mortoniceras leonensis (Conrad), mold of the interior, from top of Member A of the Georgetown formation (Locality 1.).

Fig. 2. Hamites comanchensis Adkins and Winton, mold of the interior, from base of Member A of the Georgetown formation.

Fig. 1.

Fig. 2.

Explanation of Plate X.

All figures x 1

Fig. 1. Mortoniceras kiliani (Lasswitz), mold of the interior, from Member B of the Georgetown formation at Locality 2.

Fig. 2. Prohysteroceras austinense (Lasswitz), mold of the interior, from base of Member B of the Georgetown formation at Locality 2.

Fig. 1.

Fig. 2.

Explanation of Plate XI.

All figures x 1.

Fig. 1. Leiocidaris hemigranosus (Shumard), text, from base of Member C of the Georgetown formation at Smith Branch, one-half mile east of Georgetown, Texas.

Fig. 2. Neithea wrighti (Shumard), external cast, from Member B of the Georgetown formation at Locality 2.

Fig. 3. Spondylus guadalupae Roemer, mold of the interior, from base of Austin Chalk at Locality 12.

Fig. 1.

Fig. 2.

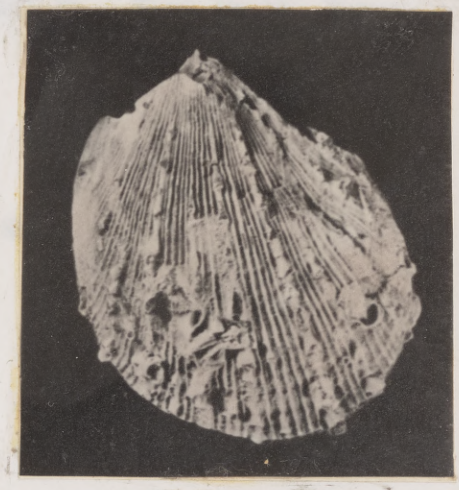


Fig. 3.

97°40'
35°40'
97°35'
30°40'
30°35'
97°40'
97°35'
30°35'

GEORGETOWN

SAN GABRIEL RIVER

SAN GABRIEL RIVER

MANSKEE BRANCH

MISSOURI-KANSAS-TEXAS

A'

EXPLANATION

Qgr	Quaternary Gravels	QUATERNARY SYSTEM
Kauf	*Exogyra ponderosa*	Gulf Series — Zones of Austin Chalk Formation
Kaue	*Ostrea travisana*	
Kaud	*Hemiaster texanus*	
Kauc	*Inoceromus undulatoplicatus*	
Kaub	*Gryphaea wratheri*	
Kaua	*Inoceromus subquadratus*	
Kef	Eagle Ford Shale	CRETACEOUS SYSTEM
	UNCONFORMITY	
Kbu	Buda limestone	
Kgr	Grayson marl	
Kgee	Member E	Comanche Series — Georgetown Formation
Kged	Member D	
Kgec	Member C	
Kgeb	Member B	
Kgea	Member A	

○ Locality

Intermittent Stream

Flowing Stream and River

U/D Known and Inferred Fault

↗ 1° Strike and Dip of Beds

DIAGRAMATIC CROSS-SECTION ALONG A - A'

WEST — EAST

FEET ABOVE SEA LEVEL 700 600 500

Kbu, Kdc, Ke, Kms, Kdr, Kef, Kau

PLATES I & II

9 1/2°

MEAN DECLINATION
9°30'E (1948)

GEOLOGIC MAP OF BELL GIN QUADRANGLE, WILLIAMSON COUNTY, TEXAS.

by
BILL WALLS*

SCALE - 1:20,000

0 5000 10000 Feet

Base from U.S.G.S. Topographic Maps and U.S. Department of Agriculture Photographs.

* Department of Geology
The University of Texas

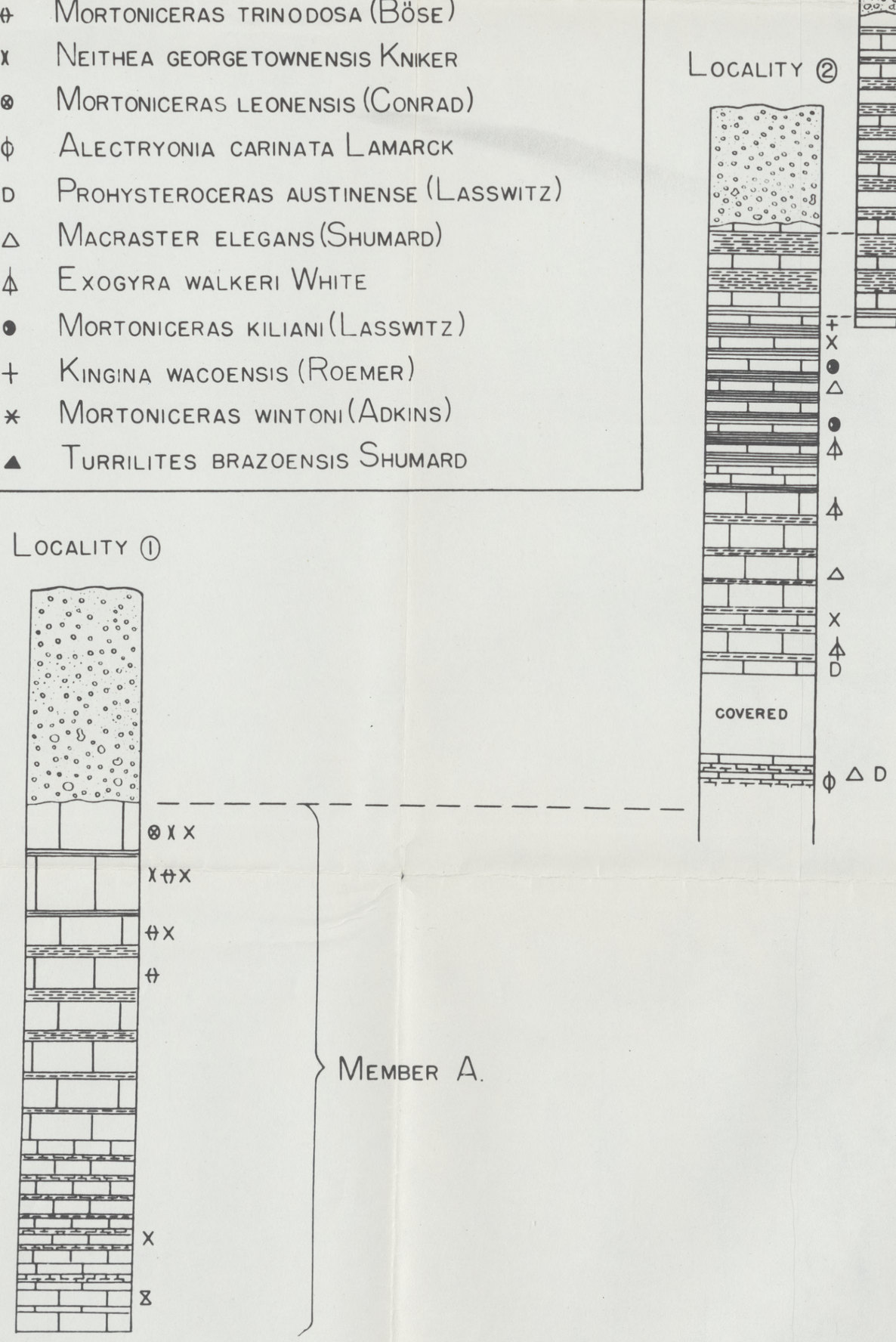
COMPOSITE SECTION OF THE GEORGETOWN FORMATION IN BELL GIN QUADRANGLE WILLIAMSON COUNTY, TEXAS

BILLY WALLS-AUGUST, 1950

T1950
W159

FOSSILS

- ⧖ Desmoceras brazoense Shumard
- X Gryphaea washitaensis Hill
- ⊖ Mortoniceras trinodosa (Böse)
- ✕ Neithea georgetownensis Kniker
- ⊗ Mortoniceras leonensis (Conrad)
- ϕ Alectryonia carinata Lamarck
- D Prohysteroceras austinense (Lasswitz)
- △ Macraster elegans (Shumard)
- ⍋ Exogyra walkeri White
- ● Mortoniceras kiliani (Lasswitz)
- \+ Kingina wacoensis (Roemer)
- * Mortoniceras wintoni (Adkins)
- ▲ Turrilites brazoensis Shumard



LITHOLOGY

- Gravel
- Limestone
- Marl
- Shale
- Shaly Limestone

WEST

Horizontal Scale 1" = 500'

Vertical Scale 1" = 6'

EAST

The vita has been removed from the digitized version of this document.